Appendix A: Collector Sizing

Collector sizing depends on the magnitude of the building ventilation and the wall area available for mounting the transpired solar collector.

V_{bldg} = building outdoor airflow rate — **12,000** cfm

A_{avai} = available wall area for collector — **2,000** ft^2

v_{min} = minimum collector flow rate (typically about 4 cfm/ft^2) — **4** cfm/ft^2

v_{max} = maximum collector flow rate (typically about 8 cfm/ft^2) — **8** cfm/ft^2

A_{min} = minimum collector area (ft^2)

A_{max} = maximum collector area (ft^2)

A_{coll} = design collector area (ft^2)

V_{coll} = total flow rate through the collector (cfm)

v_{coll} = flow rate per unit collector area (cfm/ft^2)

$$A_{min} = \frac{12{,}000}{V_{bldg}} \div \frac{8}{V_{max}} = 1{,}500 \text{ ft}^2$$

$$A_{max} = \frac{12{,}000}{V_{bldg}} \div \frac{4}{V_{min}} = 3{,}000 \text{ ft}^2$$

1) if $A_{avail} > A_{max}$, then

$A_{coll} = A_{max}$ = _____ ft^2

$V_{coll} = V_{bldg}$ = _____ cfm

$v_{coll} = v_{min}$ = _____ cfm/ft^2

2) if $A_{min} < A_{avail} < A_{max}$, then

$A_{coll} = A_{avail}$ = **2,000** ft^2

$V_{coll} = V_{bldg}$ = **12,000** cfm

$v_{coll} = V_{bldg} \div A_{avail}$ = **6** cfm/ft^2

3) if $A_{avail} < A_{min}$, then

$A_{coll} = A_{avail}$ = _____ ft^2

$V_{coll} = A_{avail} \times v_{max}$ = _____ cfm

$v_{coll} = v_{max}$ = _____ cfm/ft^2

Annual Energy Savings

A_{coll}	=	collector area	**2,000**	ft^2
t_{hours}	=	time that there is airflow through the collector (length of collector operating day)	**16**	hours/day
t_{days}	=	time that there is airflow through the collector (length of collector operating week)	**5**	days/week
t_{weeks}	=	time that there is airflow through the collector (length of collector operating season)	**35**	weeks/year
q_{solar}	=	useful energy from the collector (from Map 1)	**120**	$kBtu/ft^2$-year
q_{fan}	=	fan energy for airflow through the collector (typically about 1 W/ft^2)	**1**	W/ft^2
U_{wall}	=	heat loss coefficient for the building wall	**0.1**	$Btu/°F$-ft^2-hour
HDD	=	annual heating degree-days (from Map 2)	**5,000**	°F-days/year
E_{htg}	=	efficiency of the conventional heating system	**0.7**	fraction
Q_{solar}	=	solar energy collected (MBtu/year)		
Q_{wall}	=	wall heat recapture (MBtu/year) (only significant for very poorly insulated walls)		
Q_{saved}	=	thermal energy savings (MBtu/year)		
Q_{fan}	=	fan energy use (kWh/year)		

Thermal Energy Savings:

$$Q_{solar} = \underset{A_{coll}}{\textbf{2,000}} \times \underset{q_{solar}}{\textbf{120}} \times (\underset{t_{days}}{\textbf{5}} \div 7) \div 10^3 = \underline{\textbf{171}} \quad \text{MBtu/year}$$

$$Q_{wall} = \underset{A_{coll}}{\textbf{2,000}} \times \underset{U_{wall}}{\textbf{0.1}} \times \underset{t_{hours}}{\textbf{16}} \times (\underset{t_{days}}{\textbf{5}} \div 7) \times \underset{HDD}{\textbf{5,000}} \div 10^6 = \underline{\textbf{11}} \quad \text{MBtu/year}$$

$$Q_{saved} = (\underset{Q_{solar}}{\textbf{171}} + \underset{Q_{wall}}{\textbf{11}}) \div \underset{E_{htg}}{\textbf{0.7}} = \underline{\textbf{260}} \quad \text{MBtu/year}$$

Electrical Energy Parasitics:

$$Q_{fan} = \underset{A_{coll}}{\textbf{2,000}} \times \underset{q_{fan}}{\textbf{1}} \times \underset{t_{hours}}{\textbf{16}} \times \underset{t_{days}}{\textbf{5}} \times \underset{t_{weeks}}{\textbf{35}} \div 10^3 = \underline{\textbf{5,600}} \quad \text{kWh/year}$$